"WaveSim"

Traveling Waves (F1)

This simulates a wave traveling through a medium. The width of the screen is assumed to be 100 units. You select a wavelength of 25, 33, or 50 units. You then specify the number of waves that you want the calculator to time for you. The calculator displays and times these traveling waves. It then presents you with a screen showing how to compute the period, frequency, and speed of the waves. One can observe that the speed of the waves is independent of the wavelength

Standing Waves (F2)

This simulates a string that is fixed at both ends. You select the mode of vibration (1, 2, or 3), and then enter the number of cycles that you want the calculator to time for you. The screen then shows an animation with two traveling waves moving in opposite directions and the resulting standing wave. After the animation a screen provides calculations for the period, frequency, wavelength, and speed of the wave. Students can conclude that the natural frequencies that produce standing waves are proportional to the mode of vibration.

Reflection and Refraction (F3)

The Parabolic Reflection option allows one to view a parabolic reflector, its focal point, and a single wave that begins at the focus as a circular wave front and reflects off of the parabolic reflector as a straight wave front. The motion then reverses with the straight wave heading toward the parabolic reflector and converging at the focal point.

The refraction options simulate straight waves approaching an air/glass interface from air to glass. You select the angle of incidence and the number of seconds that you wish to view the animation. One can clearly see that the frequency is the same in both air and glass and that the waves have slowed down in the glass, with shorter wavelengths than in air. A normal to the air-glass interface is displayed as well as rays that are perpendicular to the wave fronts. If this image is projected onto a screen then one could measure the angle of refraction and determine the index of refraction of glass.

Beats (F4)

Here one chooses from seven different combinations of frequencies for a pair of waves. On a single screen, each of the waves is shown after one second of generation along with the resulting beat pattern achieved by wave addition. It is readily observed that the beat frequency is the difference in the frequencies of the two generating waves, and the frequency of the resultant wave is the average of the frequencies of the two generating waves.

A final option for beats allows one to supply user-defined frequencies of the two generating waves. Here it is particularly instructive to select a pair of widely different frequencies, say something like 3 Hz and 20 Hz. In this case, beats are not produced, but the separate frequencies are readily distinguishable in the sum waveform. This would correspond to striking two notes on a piano keyboard that are widely separated.

Two-Point Source Interference (F5)

This simulation represents circular waves generated in step with each other from two point sources, as might be seen in a ripple tank. The source separation is selected by the user and can be varied from 1 to 5 wavelengths. The animation shows the circular waves moving away from the two sources, as well as the nodes (dark, undisturbed regions where destructive interference occurs) and antinodes (regions of constructive interference). It can be readily observed that the number of nodes on either side of the perpendicular bisector of the two sources is equal to the number of wavelengths separating the two sources. If the pattern is projected onto a screen or screen prints are captured and printed, then one can determine the wavelength from measurable characteristics of the interference pattern by a well-known physics formula used to compute wavelength from the interference pattern from light going through two closely spaced slits.

Fourier Waveforms (F6)

With this option one can see how to build up three common waveforms by adding more and more consecutive terms in the corresponding Fourier series. The user selects the saw tooth, square, or triangle waveform. The user is then asked for the order of the series, which is the number of terms to add up in the series. The user can see that increasing the order results in waves that more closely resemble the desired waveform. One notices that the triangular wave seems to converge more quickly than the other two waveforms. It should also be noted that the larger the order, the longer it will take to produce the Fourier waveform. It is suggested that orders less than 10 are best if one is limited in viewing time.

Amplitude Modulation and Attenuation (F7)

This allows one to view how amplitude modulation occurs for either a sine wave signal or a saw tooth wave signal. The user selects which of these two signals he/she wishes to study. Then the user select from several possible signal frequencies, several carrier frequencies, and the modulation index (a number between 0 and 1). The screen shows three waves as they appear after one second of generation – the signal, the carrier, and the amplitude modulated resultant wave. It is particularly interesting to note (1) how the signal is represented in the resultant AM wave, and (2) how changing the modulation index affects the AM signal that is produced.

The last choice in F7 is attenuation, or exponential damping of waves. Here one specifies at will the initial amplitude, the wave frequency, and the attenuation coefficient. The screen then shows the resultant waveform as it would appear after one second of generation. It is particularly interesting to note how sensitive the amount of damping is on small changes in the attenuation coefficient.

Doppler Effect (F8)

In this final option, one can select Mach 0.6, Mach 1, or Mach 1.8. An animation is then produced on the screen that shows the resultant wave fronts. The cone of constructive addition of wave fronts is readily noted for the case of Mach 1.8. This help in understanding the production of a shock wave, when the speed of the source exceeds the speed of the waves in the medium.